



Armed Forces College of Medicine AFCM



Cartilage

Prof. Dr. Mona Raafat
Histology Department

INTENDED LEARNING OBJECTIVES (ILO)



By the end of this lecture the student will be able to:

1- Describe the microscopic structure of cartilage cells and matrix.

2- Correlate the structure of hyaline cartilage, elastic cartilage and white fibro-cartilage to their function

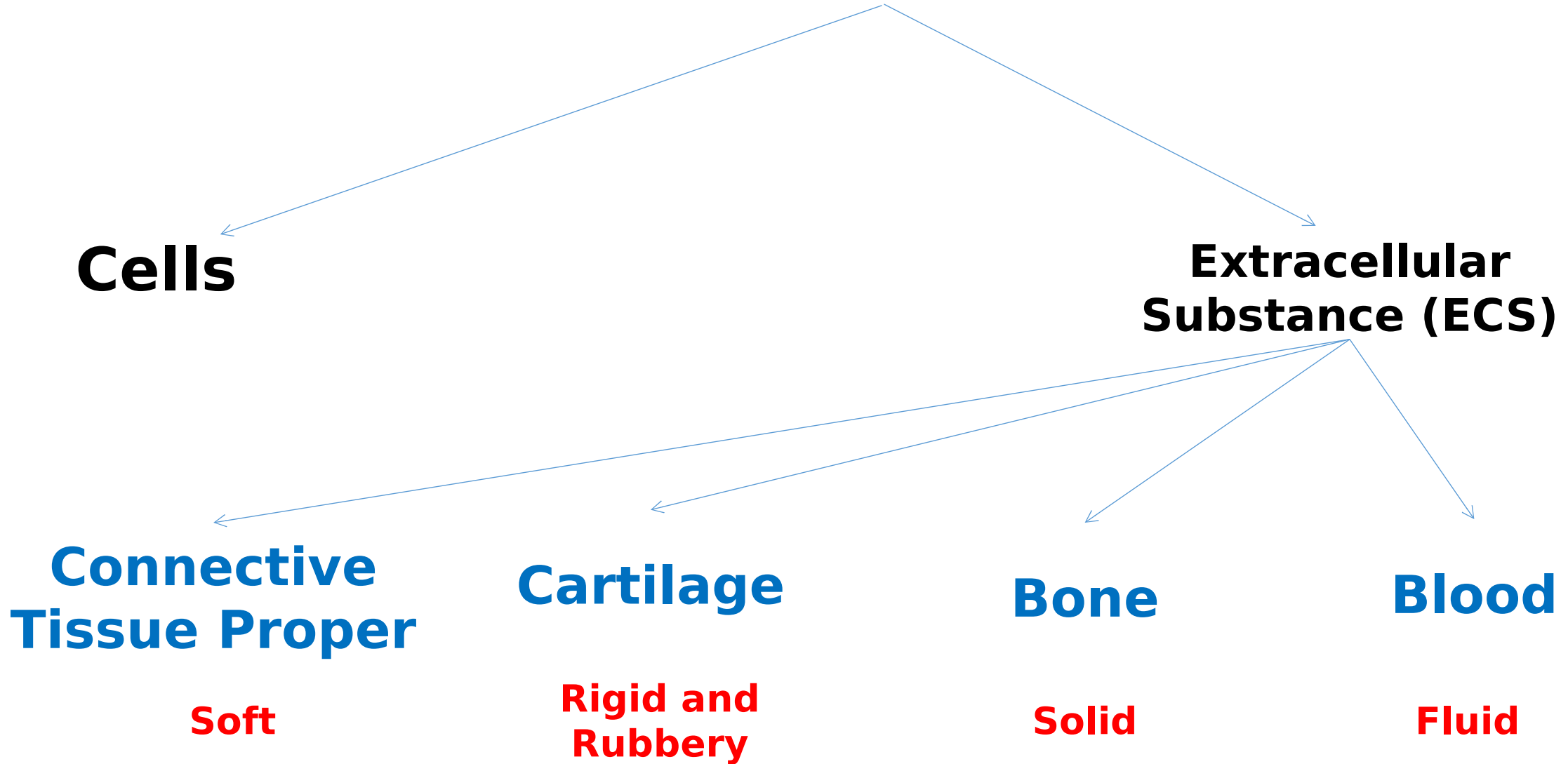
3- Interpret the defect in the microscopic cartilage structure in different diseases.

Key Points



- Histological structure of hyaline cartilage.
- Histological structure of perichondrium.
- Microscopic structure & function of different types of cartilage cells (chondrogenic, chondroblast and chondrocytes).
- Microscopic structure of the matrix of hyaline cartilage.
- Differentiate between the three different types of cartilage (Hyaline, Elastic & white-fibrocartilage).
- Staining properties of cartilage.
- Nutrition, growth and medical application of cartilage.

Connective Tissue



Cartilage



- Is a special type of connective tissue that has extra cellular matrix of a firm consistency that allows the tissue to bear mechanical stresses without permanent distortion
- Is rigid, rubbery with some degree of flexibility.
- Is well adapted to bear weight.
- **It lacks nerves**
- **No blood vessels within cartilage (avascular).**



Cartilage

- In most places cartilage is covered by **perichondrium** (connective tissue covering)
- The **Cartilage** is formed of:

1- Cells.

2- Fibers (type II collagen)

3-

Matrix of
cartilage

Types of Cartilage



- 1. Hyaline cartilage:** having matrix containing **collagen type II** fibers.
- 2. Elastic cartilage:** having matrix containing **elastic fibers + collagen type II** fibers.
- 3. White fibrocartilage:** containing **collagen type I + collagen type II** in matrix.

Hyaline Cartilage



Is the **most common** type of cartilage in the body.

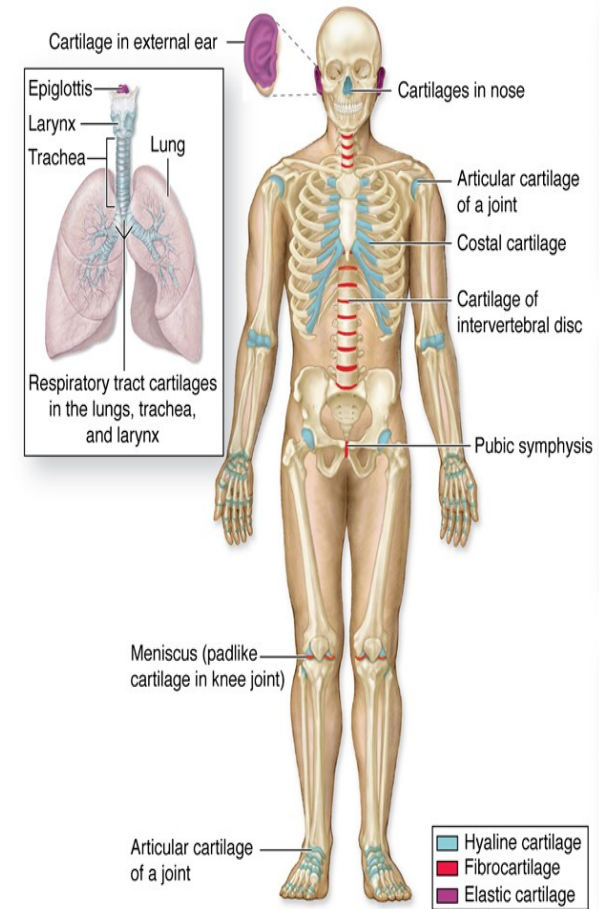
It is semitransparent in the fresh state.

Sites:

-In fetus: is present in **fetal skeleton** → replaced gradually by bone.

- In adult, it is located in:

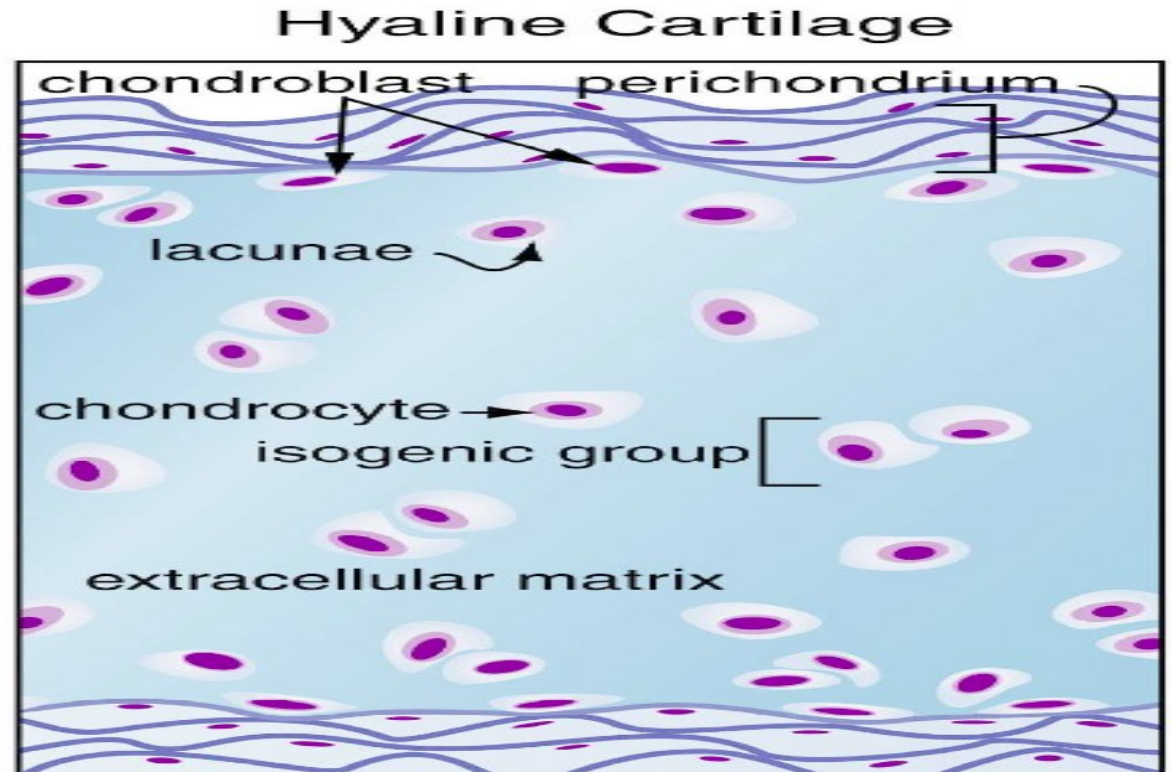
1. Articular surfaces of bone in joints.
2. Costal cartilage.
3. Respiratory passages
4. Epiphyseal plates of long bone.



Structure of Hyaline Cartilage

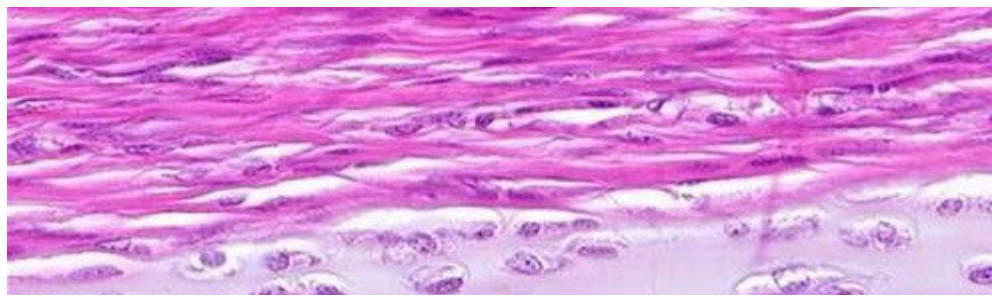


1. Perichondrium
2. Cells
3. Matrix



http://www.auburn.edu/academic/classes/zy/hist0509/html/Lec05Bnotes-cart_bone_bloo_files/image003.png

[http://undergraduate.vetmed.wsu.edu/
images/librariesprovider8/VPh308/
_blivf1_wsu_2_068_3.jpg?
sfvrsn=c8f31838_4](http://undergraduate.vetmed.wsu.edu/images/librariesprovider8/VPh308/_blivf1_wsu_2_068_3.jpg?sfvrsn=c8f31838_4)



1

2



Perichondrium

**1- Outer
fibrous
layer**

**2- Inner
chondrogenic
(cellular) layer**

**Collagen I,
fibroblasts,
blood vessels,
and neural
component**

**1 or 2 rows of
cartilage forming
cells
(chondrogenic
cells &
Chondroblasts)**

Perichondrium



➤ It is a dense irregular connective tissue membrane that covers the cartilage.

Function:

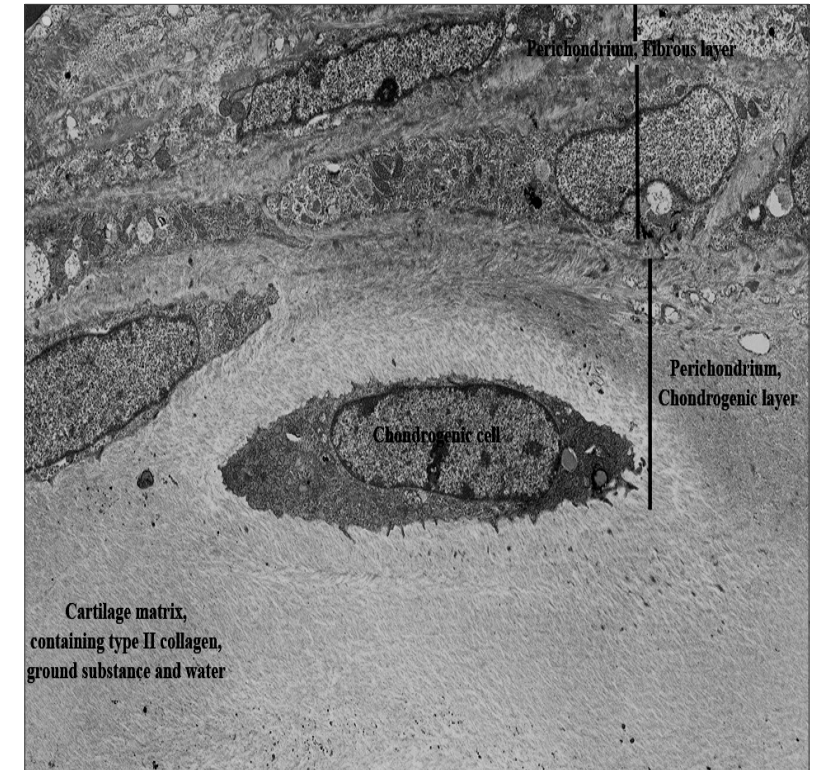
1. Supply nourishment to the **avascular** **hyaline cartilage** by **diffusion** (**except** for articular surface).
2. Growth of cartilage (**appositional**).
3. Repair & healing of damaged cartilage.

2- Cartilage Cells:



1- Chondrogenic Cells:

- **Origin:** UMC
- **Site:** inner chondrogenic layer of the perichondrium.
- **Shape:** flat or spindle.
- **L.M:** basophilic cytoplasm & ovoid flat nucleus.
- **E.M:** abundant ribosomes, few rER and golgi.
- **Fate:** they can divide and differentiate into chondroblasts



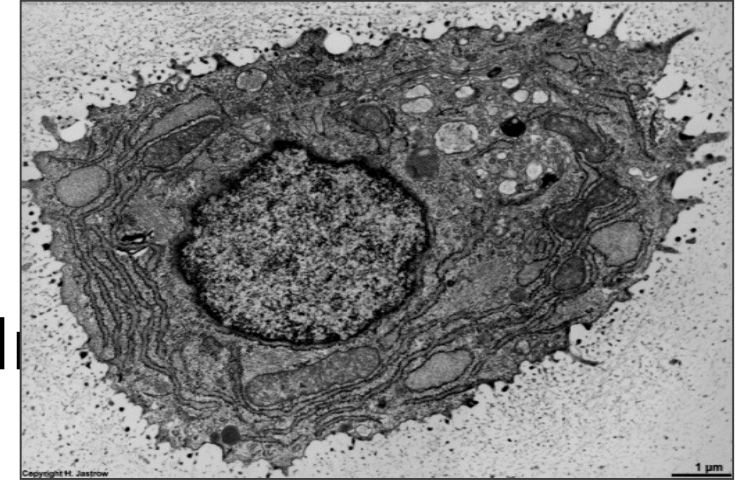
https://www.google.com.eg/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=2ahUKEwi-tPX6zP_hAhXjxIUkHXURD08QjRx6BAgBEAQ&url=http%3A%2F%2Fjcb.rupress.org%2Fcontent%2Fjcb%2F48%2F3%2F580.full.pdf&psig=AOvVaw3tL4jyrZPXqusTTieAYwr2&ust=1556981098487021

2- Cartilage Cells:

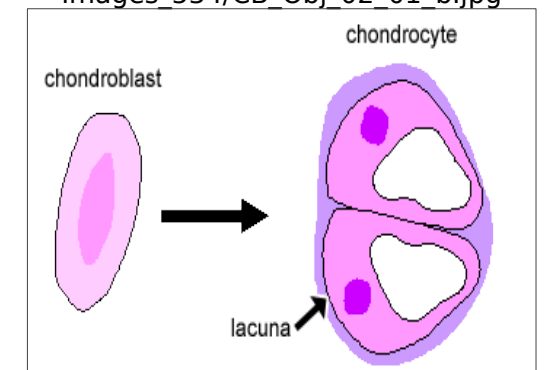


2- Chondroblasts:

- **Origin:** UMCs, chondrogenic cells or pericytes.
 - Present in inner chondrogenic layer of perichondrium.
 - **L.M.:** flat in shape, parallel to surface having central oval vesicular **nucleus** & deep **basophilic cytoplasm**.
 - **E.M.:** numerous mitochondria, ribosomes, rER & well-developed Golgi complex.
 - **Function:** They **divide** & **secrete the matrix**.
- Once surrounded by matrix, they become



http://kobiljak.msu.edu/cai/virtual_microscope/Images_534/CB_Obj_02_01_b.jpg



<https://d1yboe6750e2cu.cloudfront.net/i/6b52d706a5451f99a506f670d5c0a45937e8b30b>

3- Chondrocytes:



•Origin: chondroblasts

•L.M:

Shape:

Superficially: Oval single inside lacunae.

Deeper in the cartilage, they are round and may appear in groups of up to eight cells **cell nest** that originate from mitotic divisions of a single chondroblast and are called **isogenous aggregates**.

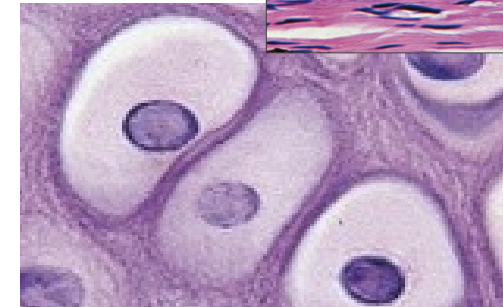
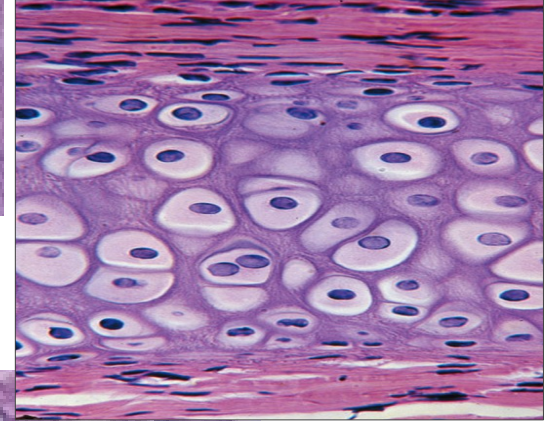
Nucleus is central, round & vesicular.

Cytoplasm is basophilic .

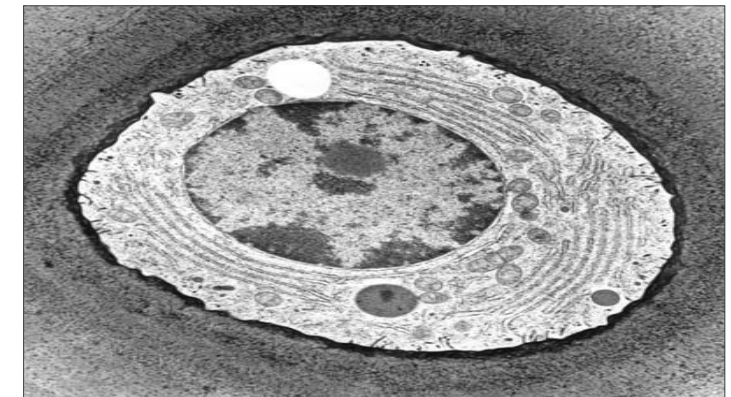
•E.M: protein secreting cells
(ribosomes- rER- Golgi - mitochondria)

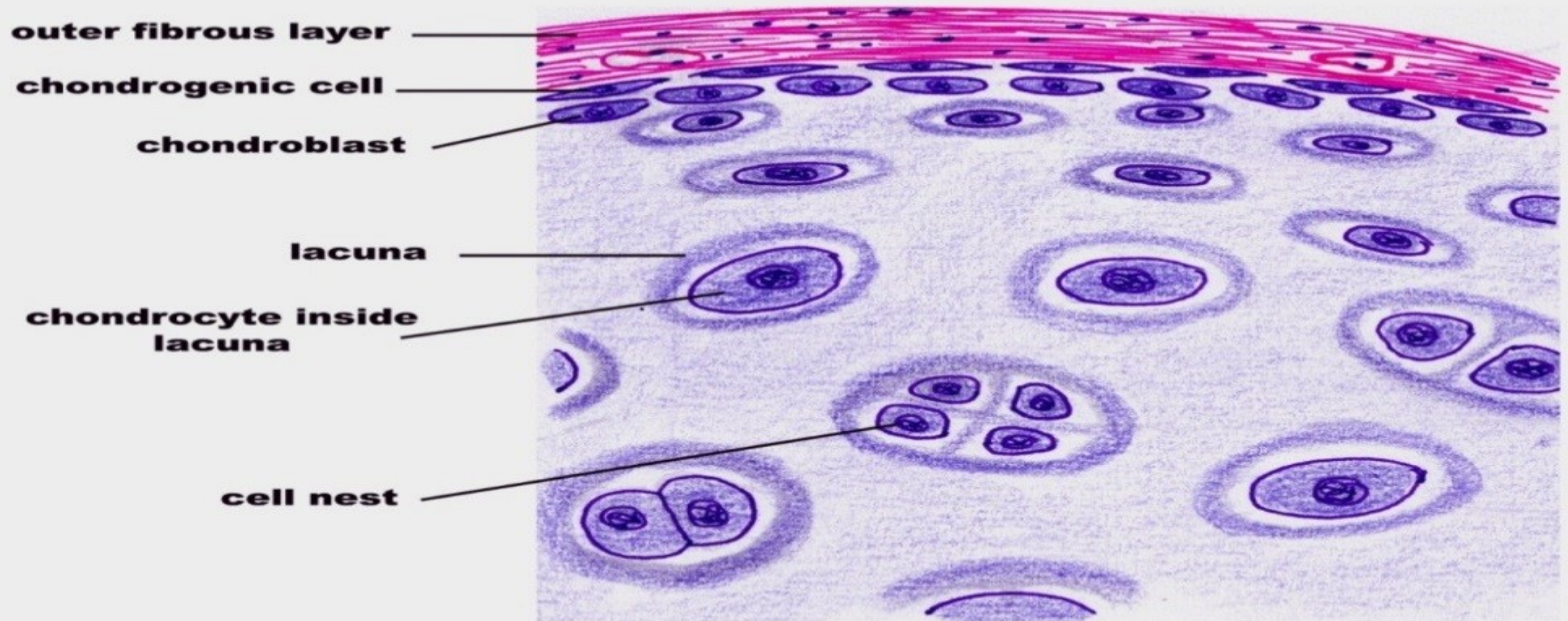
•Function:

- 1- Synthesis & secretion of matrix of cartilage
- 2- Divide (interstitial growth)



https://accessmedicine.mhmedical.com/data/books/1687/mes_ch7_f003.png38411







- **Chondroblasts :**
 - A. Have deeply acidophilic cytoplasm
 - B. Are present inside lacunae
 - C. Lead to interstitial growth of cartilage
 - ☒ D. Are flat basophilic cells in perichondrium

Lecture Quiz



- **All about chondrocytes are true except:**

- ☒ A. Non-dividable cells
- B. Flattened at the periphery when are young
- C. Have basophilic cytoplasm
- D. Present in lacunae

3- Matrix of Hyaline Cartilage:



Fibers

-mainly
collagen
type **II** fibrils

**Ground
Substances**

Tissue fluid

Causes of non apparent collagen II fibrils in H&E:

1. Have a refractive index almost the same as that of ground substances.
2. Have small submicroscopic dimensions.

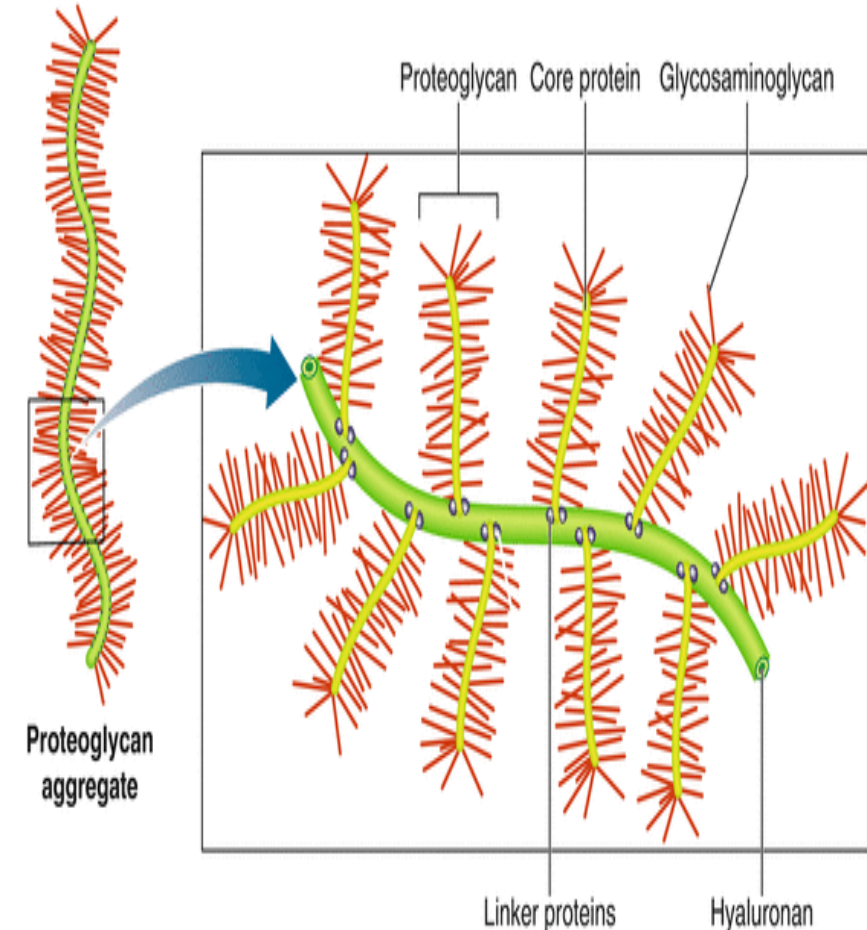
**Proteoglycans
& Glycosaminoglycans**

Glycoproteins

Ground Substances:



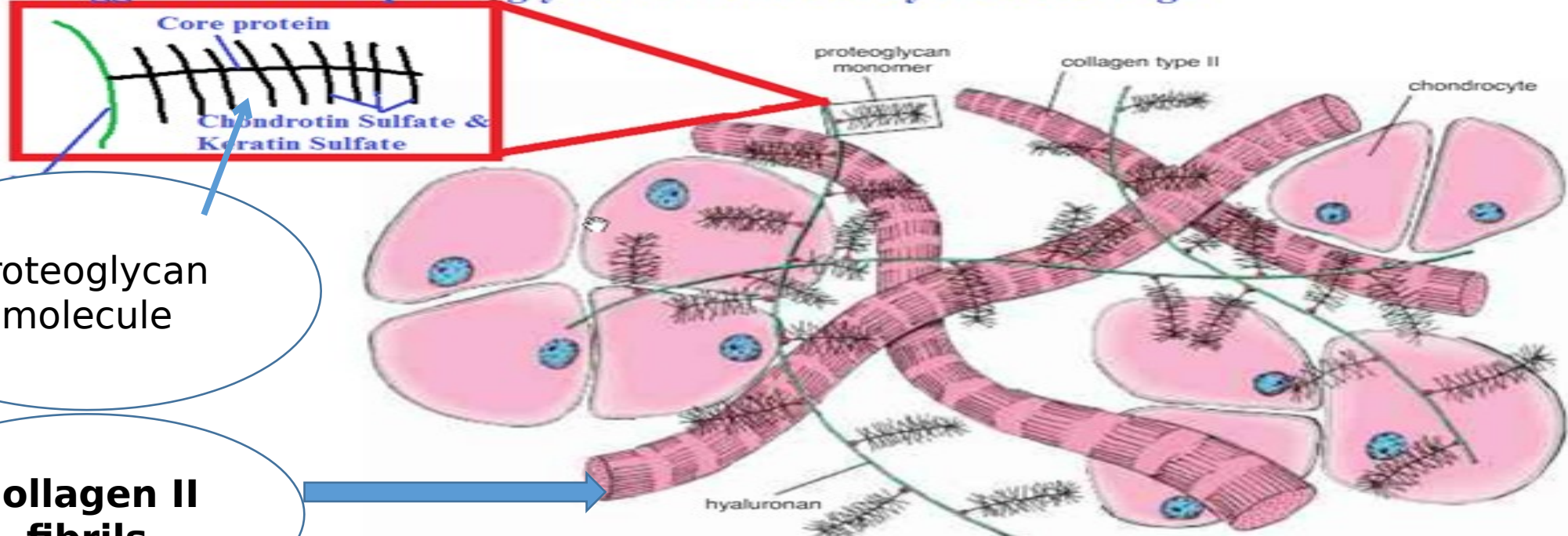
- **Tissue fluid:** forming **75% of** cartilage **weight** The high content of **bound water allows cartilage to serve as a shock absorber.**
- **Proteoglycans:**
Core of protein **aggrecan** with side chains of sulfated GAGs are attached .
- **Glycosaminoglycans (GAGs):**
Sulfated GAGs as Chondroitin sulfate, Keratan sulfate and non-sulfated Hyaluronic acid
- **Glycoproteins:** as adhesive **chondronectin** (binds to GAG and integrins)



https://media.springernature.com/original/springer-static/image/chp%3A10.1007%2F978-3-319-41873-5_7/MediaObjects/333516_1_En_7_Fig1_HTML.gif

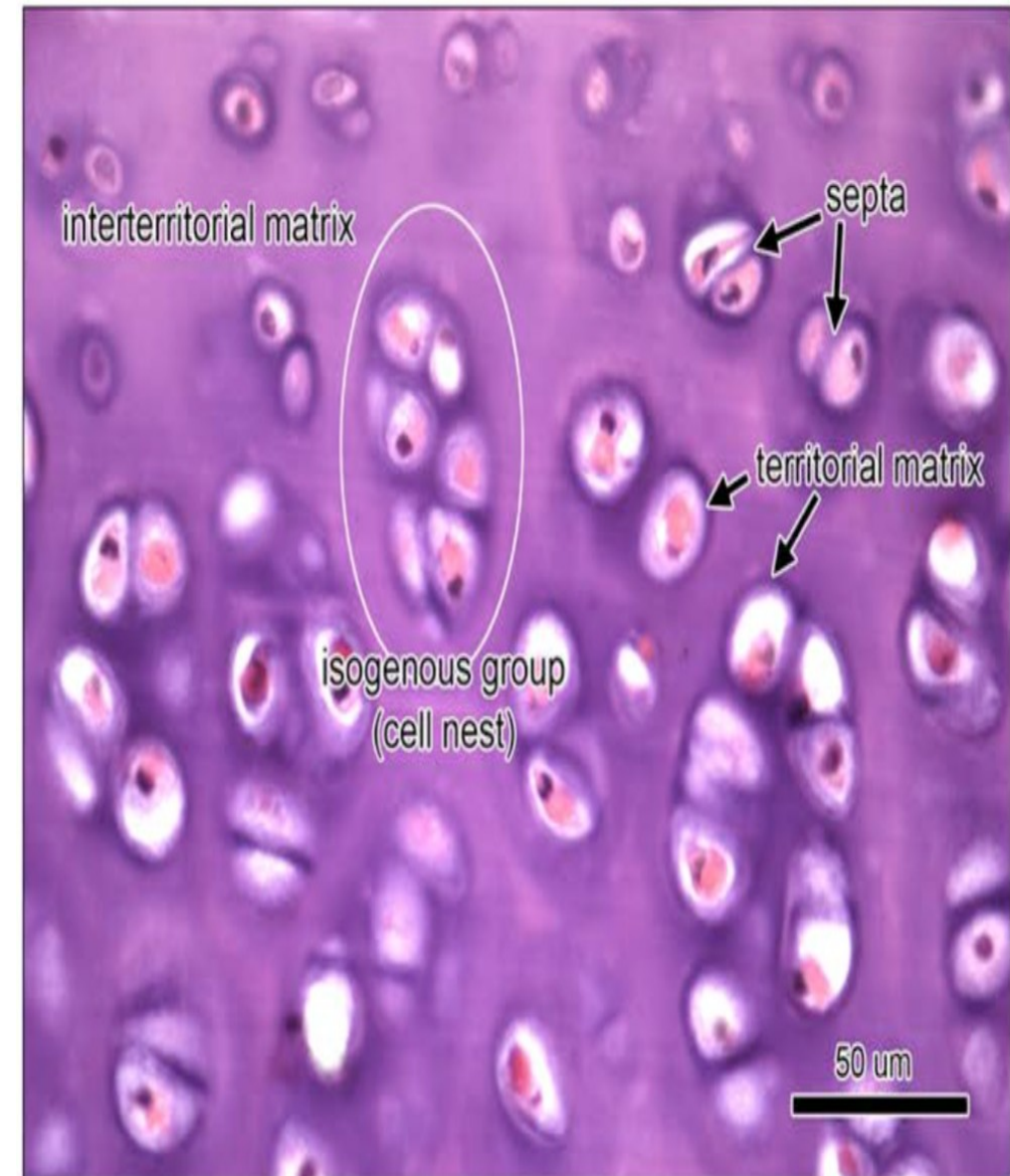
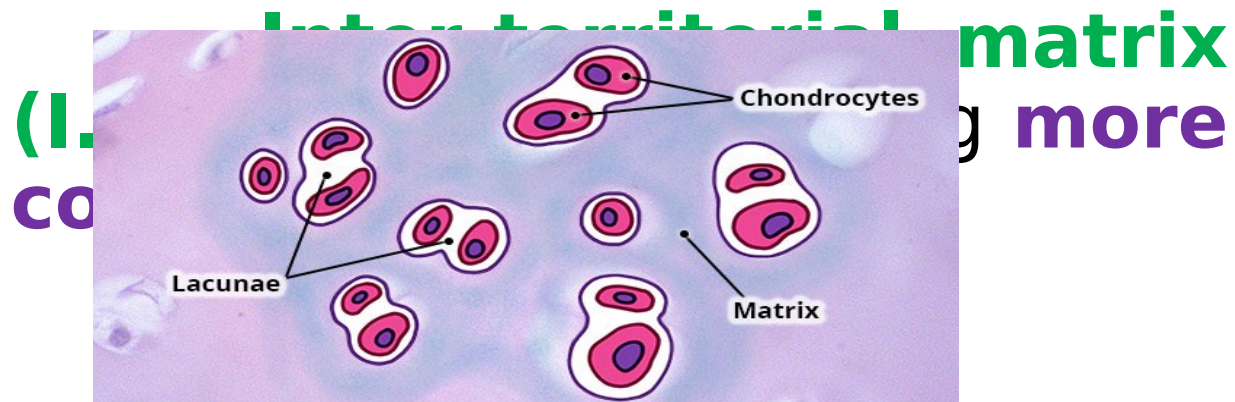
Matrix of hyaline cartilage

Aggrecan - main proteoglycan monomer in hyaline cartilage



Its **semirigid consistency** is attributable to **water bound to the negatively charged hyaluronan and GAG chains** extending from proteoglycan core proteins, which are enclosed within a dense meshwork of thin type II collagen fibrils.

- **Chondrocytes:** → within **lacunae** that are surrounded by deep basophilic capsular region or **territorial matrix (T.M.)** due to increased content of sulfated glycosaminoglycans.



<https://liti-adx.adelaide.edu.au/human.biology/cells/img/connective/Hyaline-Cartilage-Tissue-2.jpg>

Staining Properties



- Cause of matrix basophilia → high content of chondroitin sulfate.
- Cause of matrix metachromasia → presence of GAGs.
- Cause of matrix positive PAS staining → its content of glycoproteins.

• **Changes with age:** partial calcification

Lecture Quiz



- **All the followings about hyaline cartilage are true except:**
 - A. Is found in fetal skeleton
 - B. Is non-vascular
 - ☒ C. Its matrix is acidophilic
 - D. Receives its nutrition by diffusion from capillaries in perichondrium

Yellow Elastic Cartilage



- In the **fresh state**, it appears opaque and yellow in color.
- It is **present in** areas where more flexibility and elasticity is needed.

•Sites

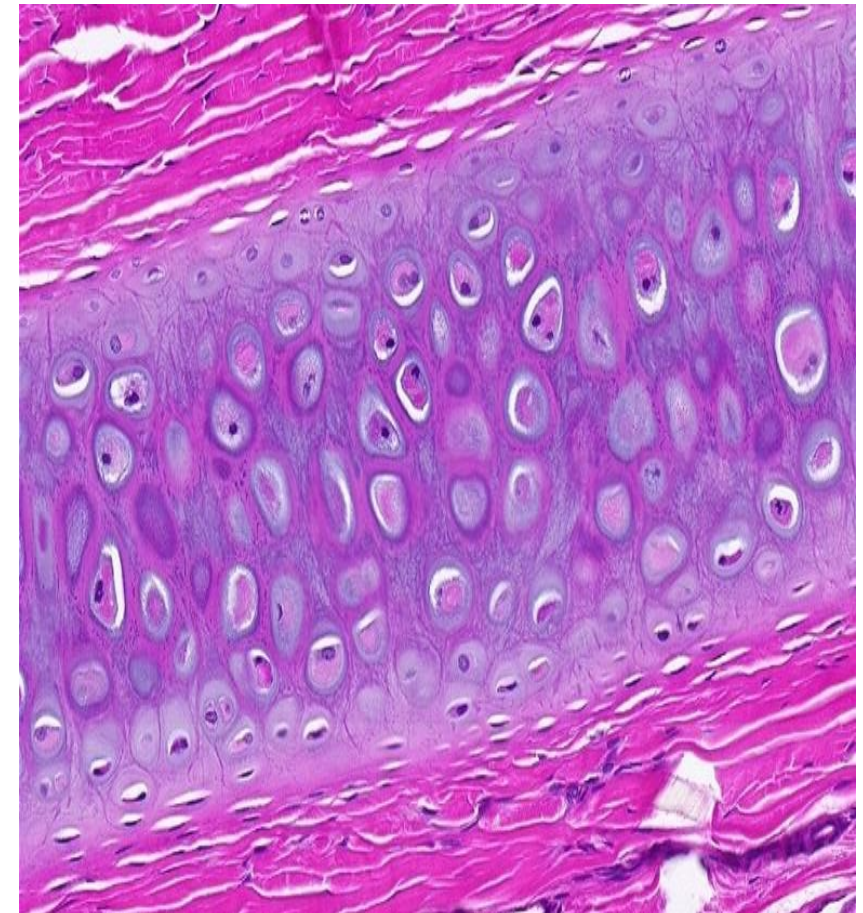
1Ear pinna.

2External auditory meatus.

3Eustachian tube.

4Epiglottis

5Tip of arytenoid cartilage of the larynx.



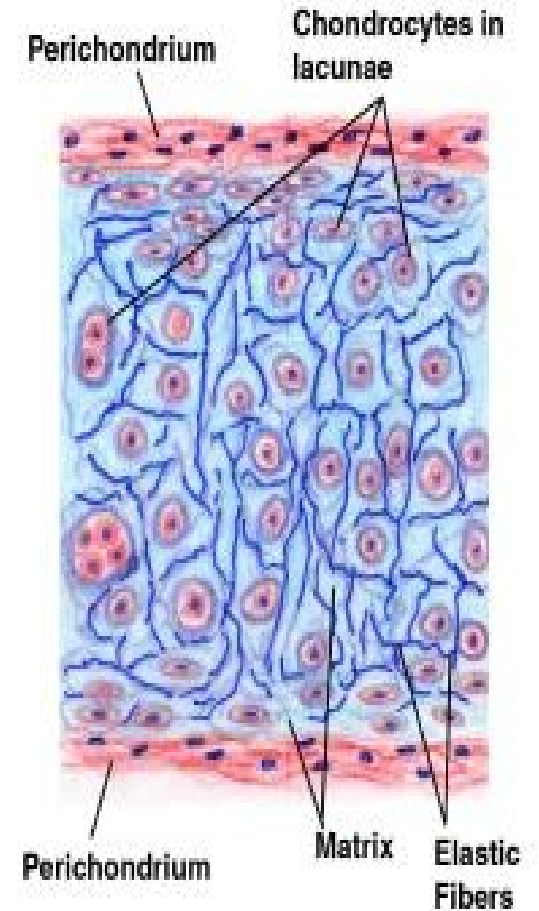
https://undergraduate.vetmed.wsu.edu/images/librariesprovider8/VPh308/img_0001_2.jpg?sfvrsn=1af01838_3

Yellow Elastic Cartilage



Structure

- Similar to hyaline cartilage, but matrix contains elastic fibers forming a network that surround the lacunae of chondrocytes.
- It is more cellular with less matrix.
- Cells are present singly or in a group of two cells in lacunae.



<https://www.histology.leeds.ac.uk/bone/assets/elastic.gif>

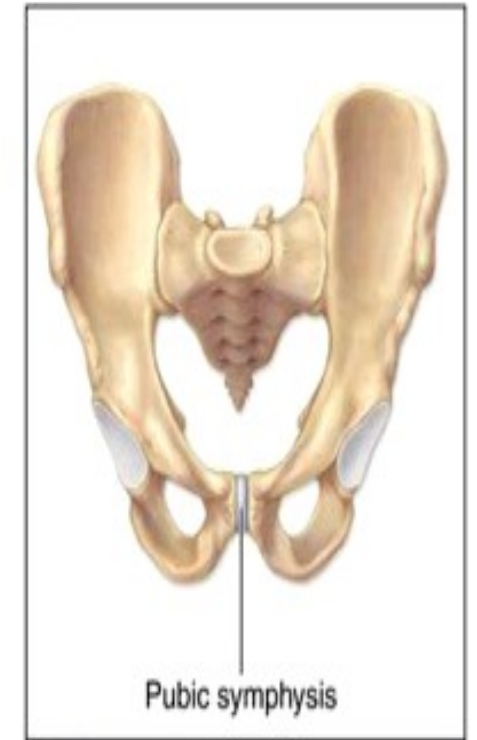
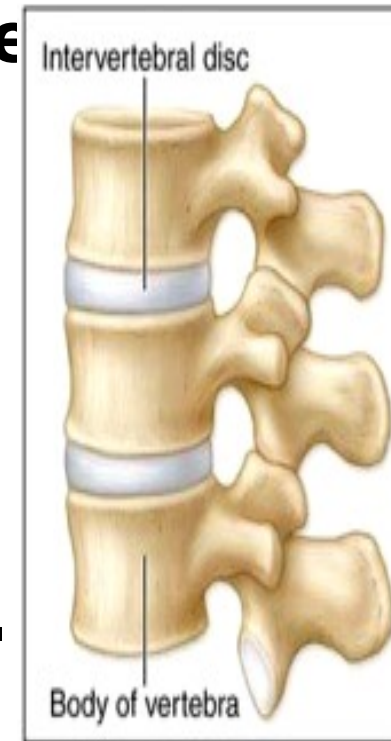
https://classconnection.s3.amazonaws.com/287/flashcards/3189287/jpg/elastic_cartilage_with_label_copy-144ACCB09A37171EC85-thumb400.jpg

White Fibro-cartilage



• In the **fresh state**, it appears white
Sites (areas of severe stress)

- Inter vertebral disc.
- Symphysis pubis.
- Lips of glenoid cavity and acetabulum.
- Semilunar cartilage of knee joint.
- Site of insertion of tendons into bones



(b) Symphyses (contain fibrocartilage)

[https://www.google.com.eg/url?](https://www.google.com.eg/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=2ahUKewjg5ojf9ZDiAhXU8OAKHfOVCuQQjRx6BAGBEAQ&url=https%3A%2F%2Fksumsc.com%2Fdownload_center%2F1st%2F2.%2520Musculoskeletal%2520Block%2FTeam%2520Work%2FAnatomy%2FLecture%2520%25282%2529%2520Joints.pdf&psig=AOvVaw1Ef097CY6FWF...1557576225425542)

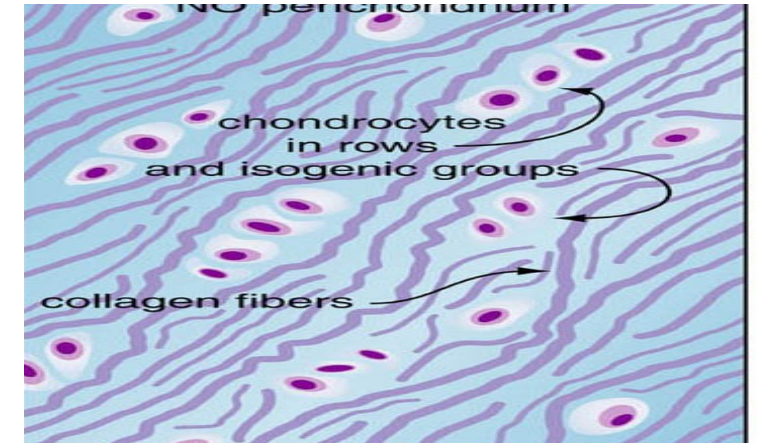
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White Fibro-cartilage



• Structure

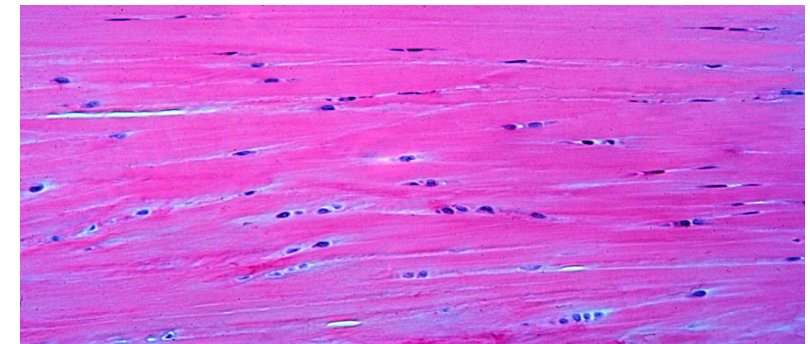
1. Areas of **chondrocytes and hyaline matrix** separated by other areas of **fibroblasts and dense bundles of type I collagen**
2. The chondrocytes are present in rows embedded in **basophilic ground substance**.
3. It is devoid of perichondrium, **BUT** the associated collagen bundles contain blood vessels.



<http://www.auburn.edu/academic/classes/zy/hist0509/image/03fibrocartilage>.

Character and Function

- It is tense and resists stretch due to the presence of high content of collagen fibers.



<http://www.bu.edu/histology/i/03203hoa.jpg>

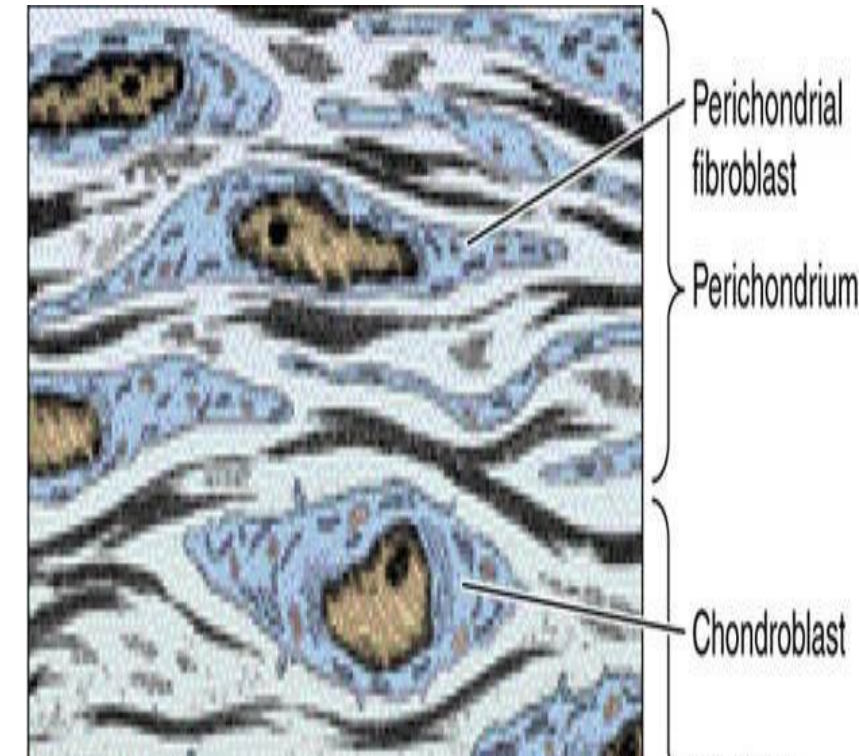


N.B:

➤ **All types of cartilage are surrounded by perichondrium**

EXCEPT:

- 1. Articular cartilage.**
- 2. White fibrocartilage.**



http://intranet.tdmu.edu.ua/data/kafedra/internal/histolog/classes_stud/uk/stomat/ntn/2/08%20%D0%A5%D1%80%D1%8F%D1%89%D0%BE%D0%B2%D1%96,%20%D0%BA%D1%96%D1%81%D1%82%D0%BA%D0%BE%D0%B2%D1%96%20%20%D1%82%D0%B0%20%D0%BC%E2%80%99%D1%8F%D0%B7%D0%BE%D0%B2%D1%96%20%D1%82%D0%BA%D0%B0%D0%BD%D0%B8%D0%BD%D0%B8..files/image005.jpg

Nutrition Of Cartilage



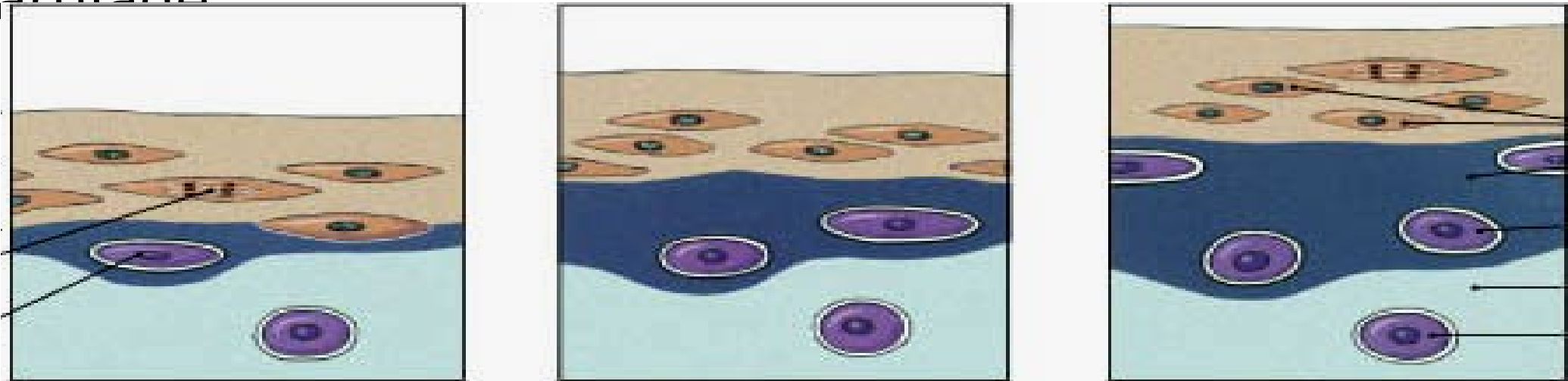
- Cartilage is **avascular**, it takes its oxygen and nutrients from the perichondrial blood vessels by diffusion through the matrix (which is suitable to that by its high content of water 70 -75%).
- **In articular cartilage** (which has no perichondrium) it gets its oxygen and nutrients from the synovial fluid of the joints.
- Also, in **white fibro-cartilage** (no perichondrium) it gets its needs from the blood vessels present in-between the bundles of collagenous fibers.

Growth of Cartilage



1- Appositional growth:

By differentiation of new **chondroblasts** in the **inner chondrogenic layer**, they divide and secrete matrix resulting in addition of new layers to the outer surface of cartilage



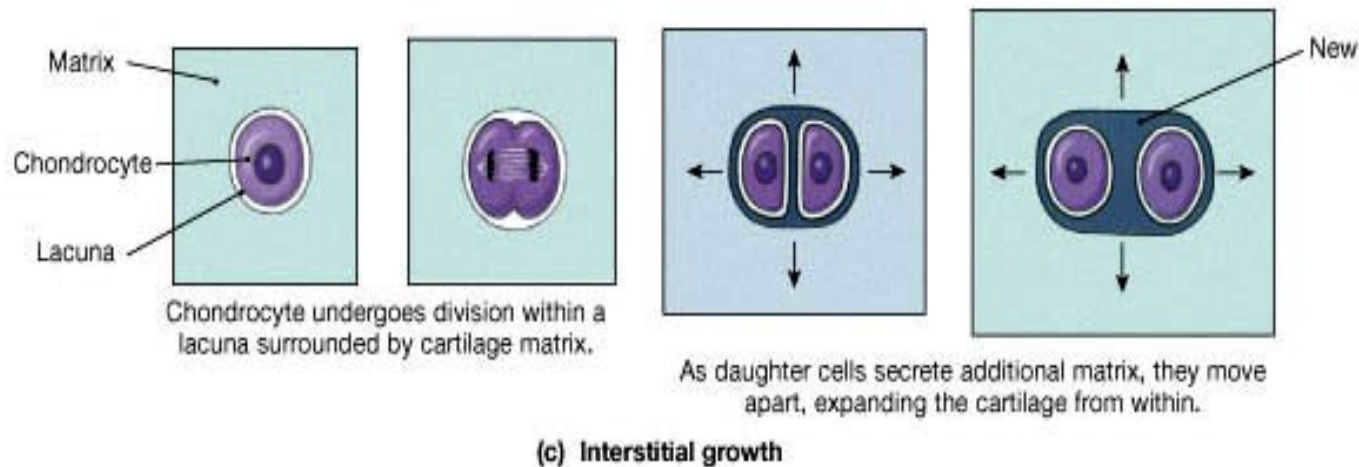
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Growth of Cartilage



2- Interstitial growth:

By **chondrocytes**, they divide inside their lacunae and secrete new matrix resulting in growth of cartilage from within.



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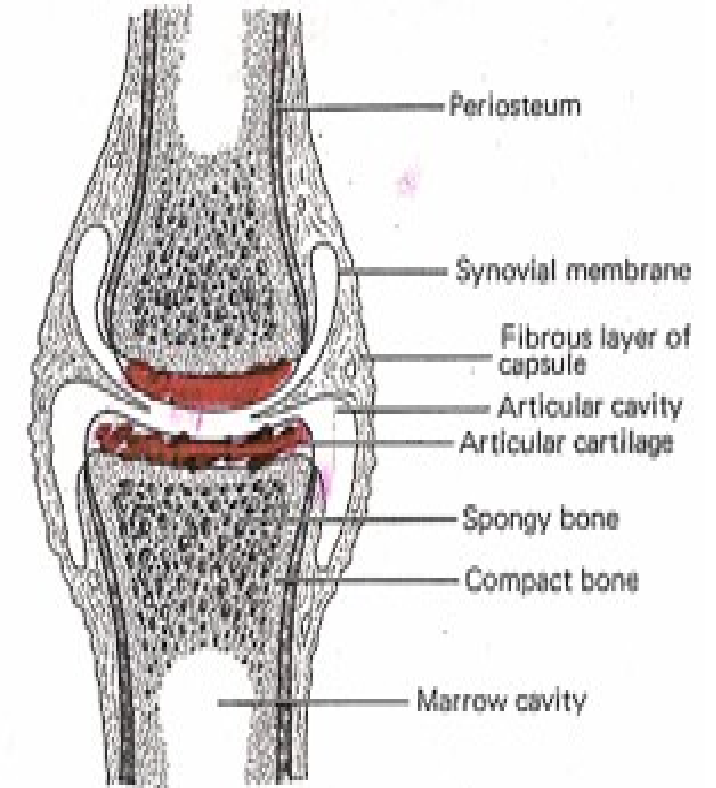
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Medical Applications



Osteoarthritis:

- Some joints like knee and hip are subjected to persistent wear and tear over the years.
- This leads to degeneration of the articular cartilage.
- Friction between the two bony surfaces cause pain.



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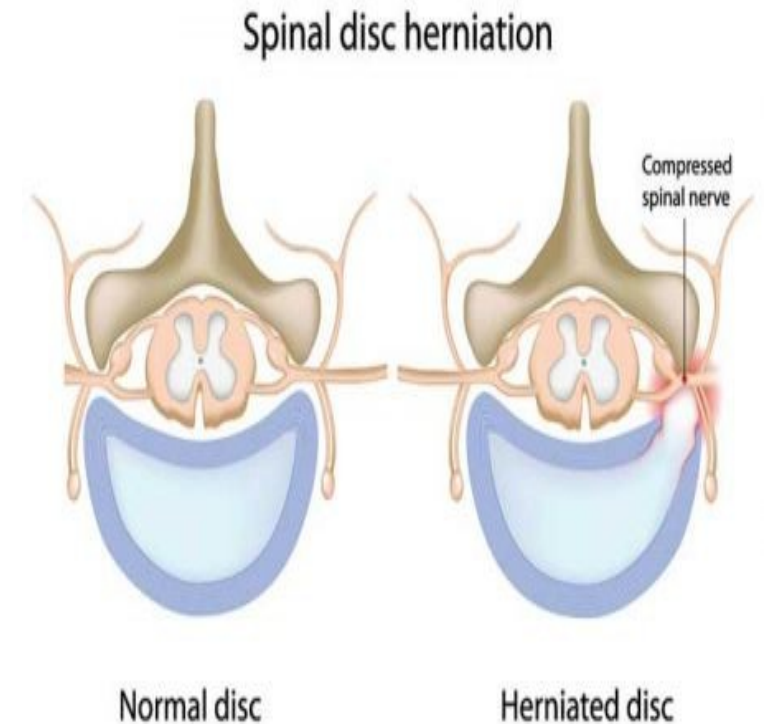
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Medical Applications



Disc prolapse:

- With advanced age, the **white fibrocartilage** of the **intervertebral disc** becomes thinned and weakened.
- Slipped discs may also be caused by abnormal heavy loads on the intervertebral discs.
- This led to herniation or prolapse of the disc which may cause pressure on the spinal nerves leading to severe pain.
- This condition commonly occurs at the lumbar region.



https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=2ahUKEwin_u6N4J_iAhVOqaQKHfunAy8QjRx6BAgBEAU&url=https%3A%2F%2Fwww.spinemd.com%2Fsymptoms-conditions%2Fdisc-herniation&psig=AOvVaw130JTBdacRO2XNXHg_QV6q&ust=1558085601820120

Fibrocartilage	Elastic cartilage	Hyaline cartilage	
Absent	Present	Present Except articular cartilage	Perichondri
Arranged in rows between bundles	Arranged single or in pairs inside lacunae	Arranged single & in groups inside lacunae	Chondrocyt
Acidophilic due to collagen I & between cells small amount of basophilic matrix with some collagen II	Basophilic , contains elastic & collagen II.	Basophilic , contains mainly collagen II.	Matrix
<ul style="list-style-type: none"> -Intervertebral discs -Semilunar cartilage -Symphysis pubis -Lip of acetabulum & glenoid -Near tendon insertion 	<ul style="list-style-type: none"> -Ear pinna -External ear -Eustachian tube -Epiglottis -Tip of arytenoid cartilage of the larynx 	<ul style="list-style-type: none"> -Articular cartilage -Costal cartilage -Cartilage of respiratory passages -Fetal skeleton -Epiphyseal plate of long bone 	Location

Lecture Quiz



- **Vascular type of cartilage is**

a) Hyaline cartilage

☒ b) White fibrocartilage

c) Elastic cartilage

d) None of the above



• **Oxygen and nutrient from perichondrial blood vessels reach the chondrocytes via:**

- a) Canaliculi
- b) Capillaries
- c) Sharpey's fibers
- d) Diffusion

Lecture Quiz



• Which of the following is true concerning
☒ white fibrocartilage

- a) It is not covered by perichondrium
- b) Cells receive their nourishment from synovial fluid.
- c) Matrix contains only Type I collagen.
- d) Is basophilic in staining

Key Points



- Histological structure of hyaline cartilage.
- Histological structure of perichondrium.
- Microscopic structure & function of different types of cartilage cells (chondrogenic, chondroblast and chondrocytes).
- Microscopic structure of the matrix of hyaline cartilage.
- Differentiate between the three different types of cartilage (Hyaline, Elastic & white-fibrocartilage).
- Staining properties of cartilage.
- Nutrition, growth and medical application of cartilage.

Summary

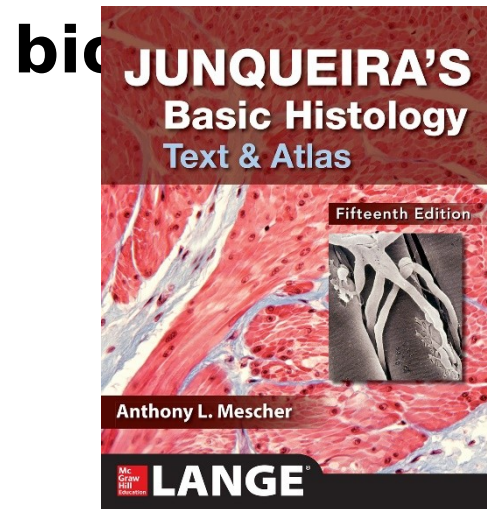


- 1. Hyaline cartilage is the most common type of cartilage**
- 2. No perichondrium in articular cartilage and white fibrocartilage**
- 3. Chondroblasts are not present in lacunae.**
- 4. Elastic cartilage has elastic fibers in their matrix**
- 5. White fibrocartilage has collagen type I in between the rows of chondrocytes**
- 6. Cartilage grows by appositional and interstitial growth**
- 7. The defective microscopic cartilage structure in hyaline and white fibro-cartilage.**

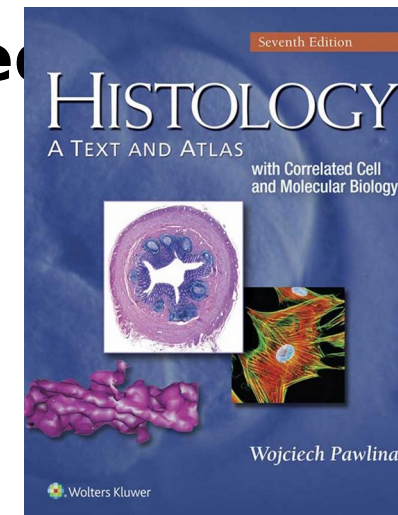
SUGGESTED TEXTBOOKS



- 1. Junqueira's Basic Histology: Text and Atlas, 15th Edition by Anthony Mescher (2018)**
- 2. Histology a text and atlas with correlated cell and molecular**



Pawlina 7th ed (2016)



THANK
YOU

